Fermilabyrinth

- Fermilabyrinth : Entrance

Warpspeed

- Fermilabyrinth : Warp Speed'
- Story: Tools: Accelerators
- Push, Push, Push the Particle
    - Push, Push, Push the Particle (Shockwave-Intro 1)
    - Push, Push, Push the Particle (Shockwave-Intro 2)
    - Push, Push, Push the Particle (Shockwave-Intro 3)
    - Push, Push, Push the Particle (Shockwave-Intro 4)
    - Push, Push, Push the Particle (Shockwave)
    - Push, Push, Push the Particle (Shockwave)
    - Push, Push, Push the Particle (Shockwave-Double)
    - Push the Particle - End
    - Student Results
- Race for Energy
    - Race for Energy (Shockwave)
    - Race for Energy (2)(Shockwave)
    - Race for Energy (Shockwave-Double)
    - Student Results

Fermilabyrinth

- Warp Speed
- Ghost Bustin'
- Code Crackin'
- Law 'n Order

Students - *Educators* - *Lederman Science Center*

Security, Privacy, Legal


Warp Speed
TOOLS: Accelerators Give Particles Oomph!
Law 'n Order
Ghost Bustin'
New Player
Code Crackin'
Diggin' Deeper
PUSH THE PARTICLE
PLAY
Race for Energy
PLAY
Read the Story
Read the Story

Accelerators Give Particles Oomph

Aerial View

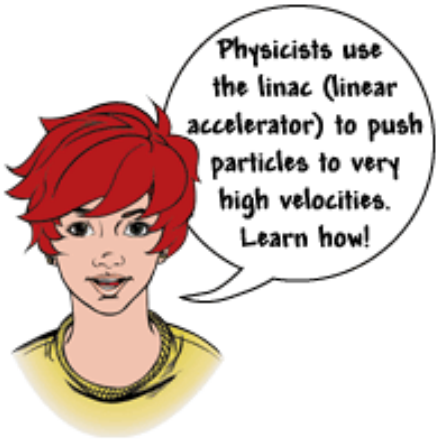
Inside the Tevatron

The Linac

The instruments that particle physicists use for their studies include accelerators, detectors and powerful computers. Accelerators give the protons enormous energy. To study very small particles scientists need very high-energy protons and very big accelerators.

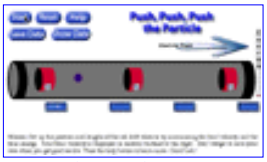
Warp Speed

Push, Push, Push the Particle

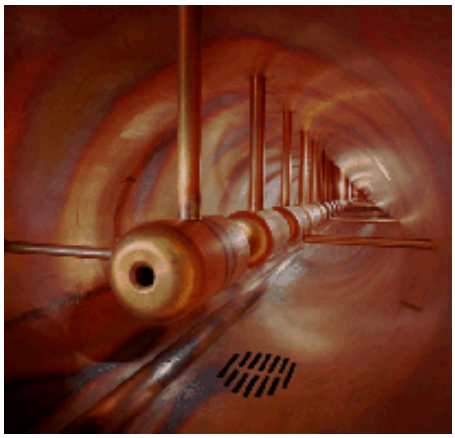


You don't have Shockwave. Get it!

This activity needs Shockwave. If you don't see the animation above, click GET SHOCKWAVE



Go to Game



Warp Speed

Web Maintainer: ed-webmaster@fnal.gov
Shockwave Movie by Vishesh Narayen, IMSA and Liz Quigg, Fermilab
Last Update: May 11, 2000
http://www-ed.fnal.gov/projects/fermilabyrinth/games/warpspeed/linac/activity.html

Push, Push, Push the Particle

Skip Introduction

Watch the purple particle as the force of the electric field pushes it forward and backward.
The arrows depict the force of the electric field, so pay close attention to them.
Can you see that it always starts with the same velocity?

Next

Warp Speed

Web Maintainer: ed-webmaster@fnal.gov
Last Update: July 2, 1999 by Vithesh Nauyen: vithesh@fnal.gov
http://www-ed.fnal.gov/projects/fermilabyrinth/games/warpspeed/linac/linac.html

Push, Push, Push the Particle

Skip Introduction

By adding shielding tubes, physicists shield the particle from the force of the electric field.
Notice how the particle is affected by the force of the electric field
only when it is outside of the shielding tube.

Back Next

Warp Speed

Web Maintainer: ed-webmaster@fnal.gov
Last Update: July 2, 1999 by Vithesh Nanayen: vithesh@fnal.gov
http://www-ed.fnal.gov/projects/labyrinth/games/warpspeed/linac/linac.html

Push, Push, Push the Particle

Skip Introduction

You can move and resize the shielding tube by dragging it and using the resize button.
Catch the particle in the shielding tube when the force of the electric field is pointing backwards.

Back Next

Warp Speed

Web Maintainer: ed-webmaster@fnal.gov
Last Update: July 2, 1999 by Vitaveth Naugsen: vitaveth@fnal.gov
http://www-ed.fnal.gov/projects/labyrinth/games/warpspeed/linac/linac.html

Push, Push, Push the Particle

Skip Introduction

Using this concept, physicists can accelerate particles to very high velocities and energies.
To do this, they must shield the particle when the force of the electric field would slow it down,
and leave it in the open when it would receive a push from the electric field.
This is exactly how linear accelerators work! Click Next to run your own trials.

Back Next

Warp Speed

Web Maintainer: ed-webmaster@fnal.gov
Last Update: July 2, 1999 by Vithesh Nauyen: vithesh@fnal.gov
http://www-ed.fnal.gov/projects/labyrinth/games/warpspeed/linac/linac.html

Push, Push, Push the Particle

Skip Introduction

Using this concept, physicists can accelerate particles to very high velocities and energies.
To do this, they must shield the particle when the force of the electric field would slow it down,
and leave it in the open when it would receive a push from the electric field.
This is exactly how linear accelerators work! Click Next to run your own trials.

Back Next

Warp Speed

Web Maintainer: ed-webmaster@fnal.gov
Last Update: July 2, 1999 by Vithesh Nauyen: vithesh@fnal.gov
http://www-ed.fnal.gov/projects/labyrinth/games/warpspeed/linac/linac.html

Trial Number	Velocity Readout Values 1	2	3	4
1	56.27	68.54	104.90	106.79
2	56.27	68.54	104.90	106.79

Push, Push, Push the Particle

More Trials | All Done!

Study your data and answer the following question.

To keep accelerating the particle as it travels further down the linac, the shielding tubes should:

- ◯ get successively longer.
- ◯ all be the same size.
- ◯ get successively shorter.

Name:

Please explain your answer.

Energy

Shielding Tube Setup For: Trial

Above are the results of all the trials you have done. Click on a trial number to see its plot. In the fields above, you should enter your name if needed and write a few sentences about your understanding of this activity. Then answer the short multiple-choice question and click **All Done** to open a printable results page where you will receive the Einstein bucks that you have earned.

Warp Speed

Web Maintainer: ed-webmaster@fnal.gov
Last Update: July 2, 1999 by Vithesh Nanayen: vithesh@fnal.gov
http://www-ed.fnal.gov/projects/labyrinth/games/warpspeed/linac/linac.html

W ould you like to try to double your score?

Yes No

The Information

As you saw in the activity, physicists use many small kicks to give the particle the very high energy that they want. However, you might have asked yourself why the electric field is not set up to always give the particle a forward push. Well, to do that, the linac would have to maintain a very high voltage difference for a long period of time. The amount of energy required to do that is unreasonably large, so the physicists had to think of a different way. Instead of giving one large push, they thought, why not give many small pushes to accelerate the particle. The easiest way to give many small, forward pushes was to have an alternating electric field, but an alternating electric field gives backward pushes as well, so that is where the shielding tube came in. Physicists refer to the shielding tubes as 'drift tubes', because the particle drifts through them.

The Problem

Before the particle enters the linac, it has an energy of 750 keV, or kilo-electron Volts (kilo- is a prefix that means 1000). By the time it leaves the linac, physicists must accelerate it to an energy of 116 MeV, or mega-electron Volts (mega- is a prefix that means million). How many times greater is the energy the particle has when it leaves the linac than the amount of energy it has when it enters the linac?

About ○ 1.5 ○ 15 ○ 150 ○ 1500 ○ 15000

All Done!

Warp Speed

Congratulations! You earned Einstein Bucks in Push, Push, Push the Particle!!

Now do you know how the Linac below works?
You can print your bucks or go back to Warpspeed.

Print Your Bucks

Go Back

Web Maintainer: ed-webmaster@fnal.gov
Last Update: May 17, 2000
http://www-ed.fnal.gov/projects/fermilabyrinth/games/lawnorder/natures_scale/done_linac.html

Marilyn Fox's Printable Results From Push the Particle

Trial Number	Velocity 1	Velocity 2	Velocity 3	Velocity 4	Relative Energy
1	53.96	84.85	113.80	108.77	83

See The High Scores

Best Trial Configuration

Marilyn Fox's answer to the question:

To keep accelerating the particle, the drift tubes have to: get longer

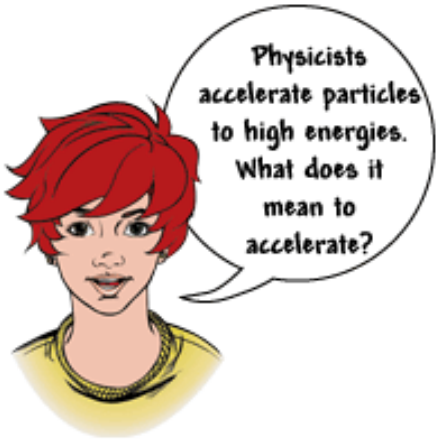
Good job! You got the answer right. As the particle speeds up, it travels a greater distance in the same amount of time. So in order to shield the particle for a given amount of time, the drift tube will have to get longer as the particle speeds up.

Marilyn Fox's explanation for his answer:

Going faster requires longer tubes.

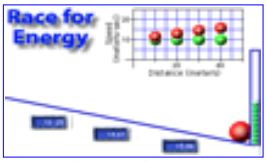
Congratulations! You succeeded in doubling your Einstein bucks!

Race for Energy



You don't have Shockwave. Get it!

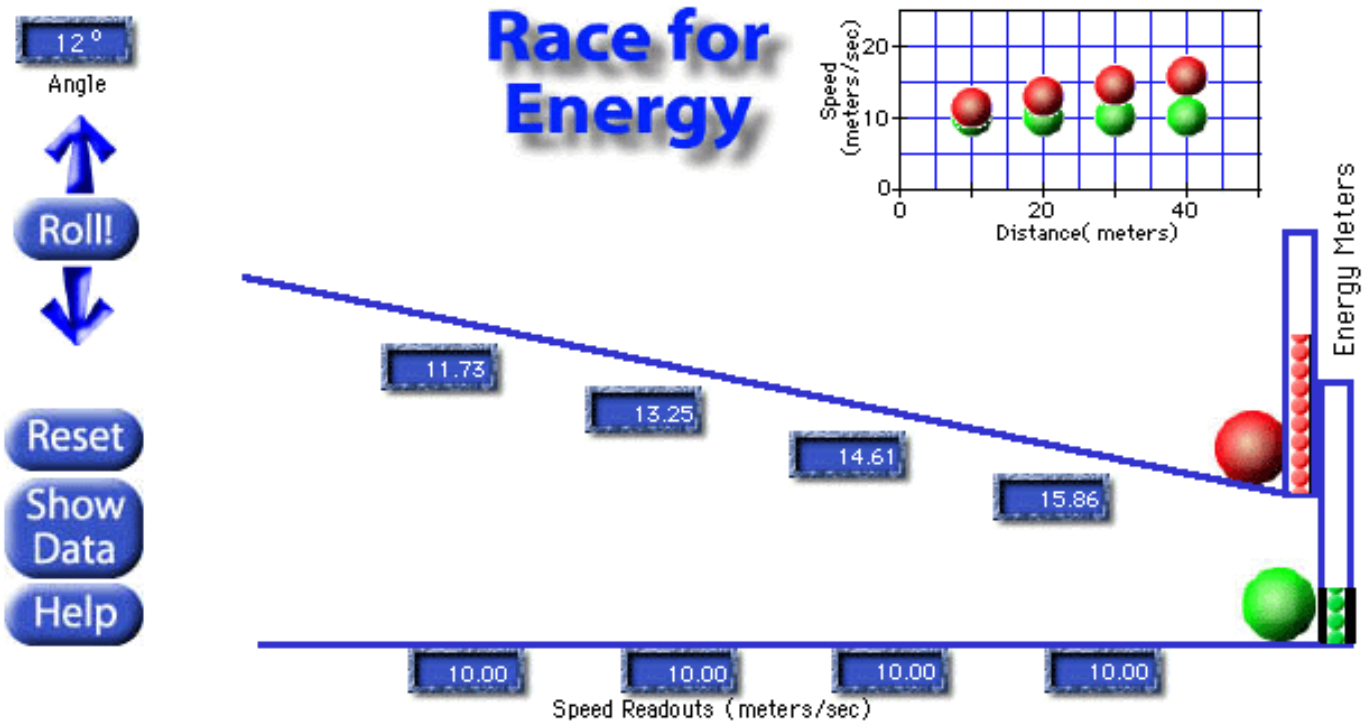
This activity needs Shockwave. If you don't see the animation above, click GET SHOCKWAVE



Go to Game

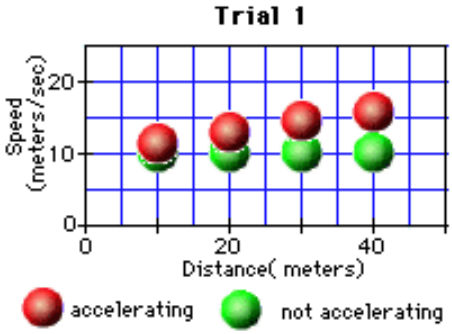
Warp Speed

Web Maintainer: ed-webmaster@fnal.gov
Last Update: Dec. 23, 1998
http://www-ed.fnal.gov/projects/fermilabyrinth/games/warpspeed/race_for_energy/activity.html

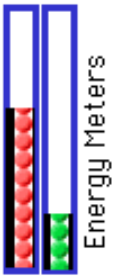


Warp Speed

Web Maintainer: ed-webmaster@fnal.gov
Last Update: June 24, 1999 by Vithesh Narayan: vithesh@fnal.gov
http://www-ed.fnal.gov/projects/fermilabyrinth/games/warpspeed/race_for_energy/race.html



Trial Number	Angle (deg.)	Speed (meters/sec) at Positions 1	2	3	4	Relative Energy
1	12	11.73	13.25	14.61	15.86	71.98
2	18	12.49	14.57	16.40	18.03	94.07



Above are the results of all the trials you have done. Click on a trial number to see its plot. In the fields below, enter your name if needed and write what you have learned about the relationship between acceleration and energy. Click **All Done** to open a printable results page.

More Trials

Name: Mary Marks

Please enter a thoughtful response below.

Study the graphs above and answer this question correctly for 100 Einstein Bucks:

Acceleration is:
- ◯ Enormous Speed
- ◯ A Change In Speed

All Done!

Warp Speed

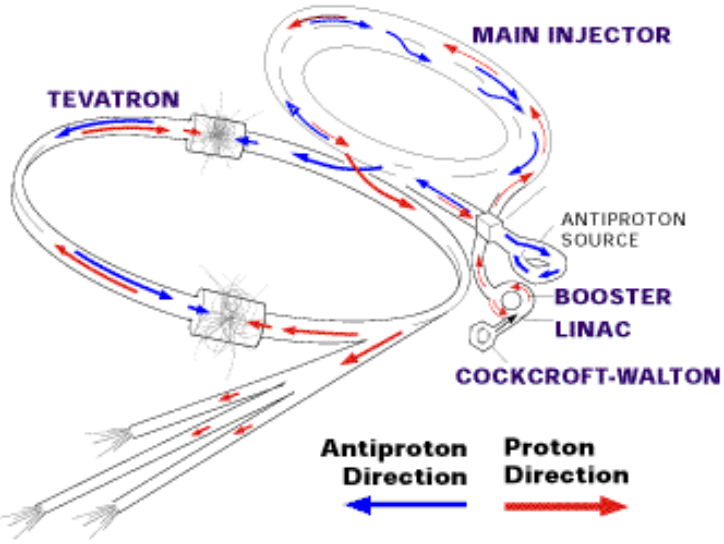
Web Maintainer: ed-webmaster@fnal.gov
Last Update: June 24, 1999 by Vikash Narayan: vikash@fnal.gov
http://www-ed.fnal.gov/projects/labyrinth/games/warpspeed/race_for_energy/race.html

W ould you like to try to double your score?

Yes No

The Information

In Race for Energy, the force of gravity accelerates the ball as it moves down the track. In the Fermilab accelerators, the force of an electric field accelerates charged particles (first hydrogen ions in the Cockroft Walton and the Linear Accelerator (Linac), and then protons in the Booster, Main Injector, and the Tevatron). In the last three stages of the accelerator, physicists use magnets to bend the path of the protons to keep them moving in a circle. Antiprotons travel in the direction opposite to the protons.



The Question

What force accelerates the particles in the Fermilab accelerator?

○ Electric Force ○ Gravity ○ Magnetism

Done

Warp Speed

Mary Loomis's Printable Results From Race For Energy

Trial Number	Angle	Position 1	Position 2	Position 3	Position 4	Relative Energy
1	12	11.73	13.25	14.61	15.86	71.7
2	16	12.25	14.15	15.84	17.34	87.83

See The High Scores

Mary Loomis's Thoughtful Response about the Relationship between Acceleration and Energy:

More acceleration means more energy.

Mary Loomis's Answer To The Question:

Acceleration is: a change in speed

Good job! You got the answer right. Acceleration *is* a change in the speed of something. It is even possible to calculate the acceleration once you know what forces are acting upon the ball and the angle that it is travelling at. In this case, gravity was pulling the ball down, and we knew the angle that it was travelling at, so we could calculate the speed at any moment.